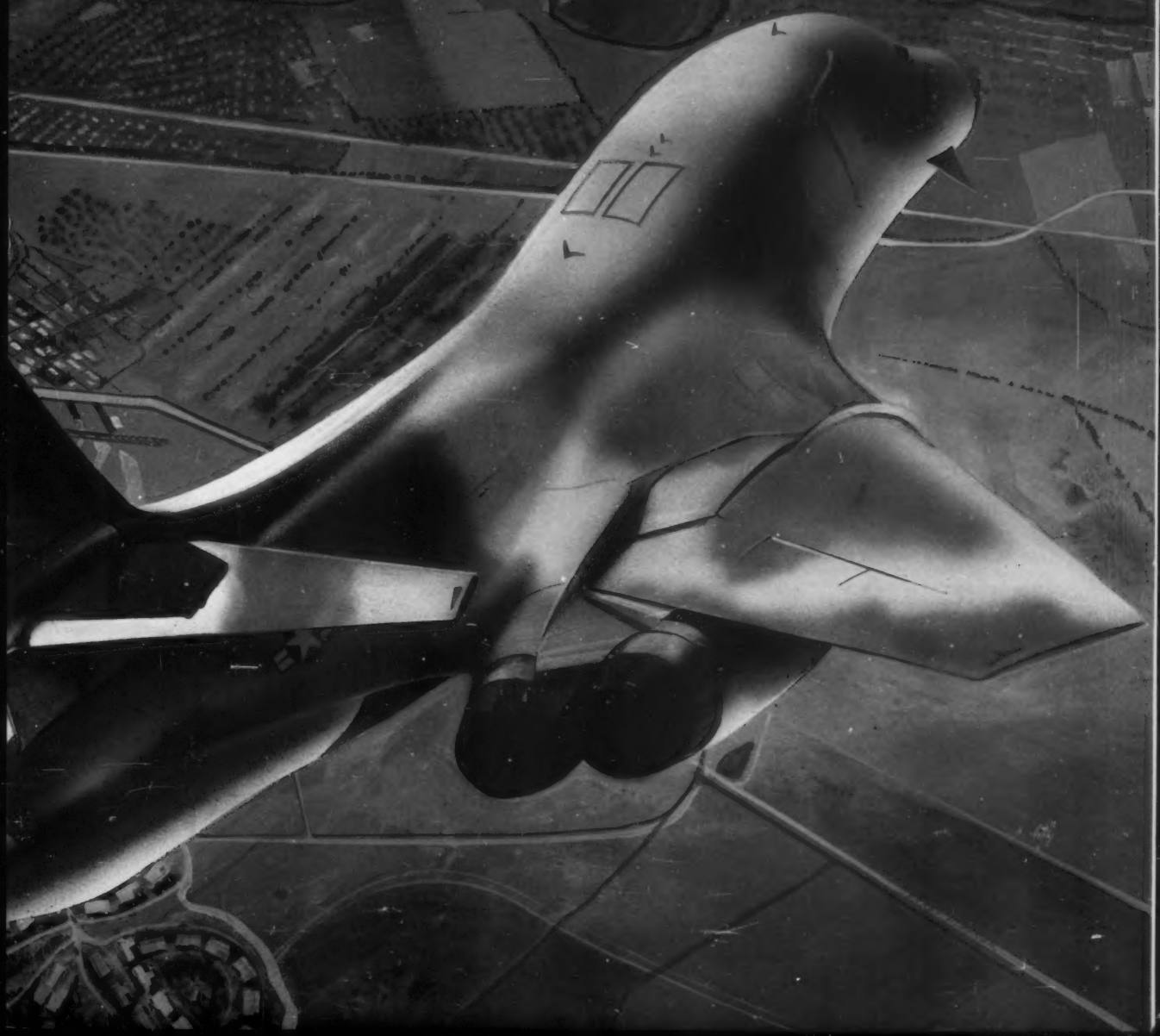
THE NAVIGATOR

AFRP 50-3, Volume 29, Number 1, Spring 1982



AFRP 50-3, Volume 29, Number 1, Spring 1982

Department of the Air Force

THE NAVIGATOR

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The B-1 is destined to become an important part of SAC in the next few years. See page 16 for more details.

A senior navigator leader gives some very good advice beginning on page 9.

Distribution: One copy per two navigators.

FROM THE EDITOR

Most of the material published in THE NAVIGATOR has been voluntarily contributed by navigators throughout the Air Force. Why not do your part toward advancing the profession? Make your ideas and experiences available to your fellow navigators by submitting them for worldwide publication in THE NAVIGATOR.

SUBJECTS: Any article relating to air navigation or the navigator career field is appropriate; therefore, an almost infinite variety of subjects is available. The choice, of course, will depend upon your particular interests. Here are some general areas to consider:

1. Informative operational experiences.
2. Improved procedures, techniques, and equipment.
3. New or proposed navigational concepts and equipment.
4. Analytical suggestions to improve the career field.

Articles should not be reprints, material readily accessible to Air Force navigators, or verbatim restatements of AFRs, AFMs, TOs, etc. Of course, classified information cannot be used.

REVIEW AND CLEARANCE: The article *must* be formally cleared for publication. This can best be accomplished through your base Public Affairs Office, who will insure that your manuscript is properly reviewed and cleared prior to release. SAC personnel should refer to SACR 5-3 for article submission procedures. Provide THE NAVIGATOR with a copy of the clearance letter attached to your manuscript.

FORMAT: Your manuscript may be prose, poetry, or cartoon with a narrative and/or technical writing style. Articles should be typed, double spaced and include a suggested title and the author's grade, name, and organizational address. Only one copy is required. Include a short biographical sketch and photograph of the author in Class A uniform.

SUPPORTIVE MATERIAL: The old saying about a picture being worth 1,000 words still applies. Carefully consider whether your manuscript would be enhanced by illustrative material. Diagrams, charts, photographs (preferably glossy black and whites), etc, are often the key to putting an idea across.

Put your improvement, innovation, humorous comment, or career-related suggestion down on paper and send it along. Our address is:

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SR-71 MACH 3+

Major Frank W. STAMPF
1 SRS
Beale AFB, CA

"One minute....pre-takeoff checks complete....30 seconds....recheck nav computer heading....15 seconds....power's coming up....10 seconds....5, 4, 3, 2, 1—HACK."

The normal jolt occurs as the brakes are released. A slight jerk from side to side as the burners kick in a split second apart, and now it takes some effort to lean forward against the acceleration in order to monitor the instruments. You watch the airspeed increase rapidly...

"Marker."

"Speed" comes the instantaneous reply from the front seat as you pass the computed acceleration checkpoint. In less than 20 seconds, you're passing through 210 knots and have lifted off the runway. Now the work *really* begins.

Again straining to lean forward in the seat, this time because of the steep climb angle, you start the familiar procedure—crosscheck attitude references, complete the takeoff checklist, check in with departure control, turn on power to the defensive and sensor systems, initiate ranging with your tanker orbiting at the ARCP—while continuing to monitor the departure, climb attitude, and airspeed.

This happens quickly, since climbing at better than 10,000 feet per minute, you reach your initial level-off at FL250 in less than 2½ minutes. At that point, it's time for the subsonic level-off checklist, a quick fix to verify the accuracy of the nav computer, self test the defensive systems, check for sensor "GO" status, and continue working the rendezvous with the tanker. You've been airborne less than six minutes.

This sequence of events is typical for the Reconnaissance Systems Officer (RSO) during the first few moments of every SR-71 sortie. Let's back up a bit, to a few hours before takeoff. Less than three hours earlier, you and your front-seater reported for a pre-mission high protein meal of steak, eggs, toast and juice. This was followed by specific mission briefings concerning today's sortie by maintenance, operations, weather, and intelligence personnel. An hour-and-a-half prior to takeoff, you received your mini-physical examination and began your suit-up, assisted by specialists from the Physiological Support Division (PSD) in donning your full pressure suit. A derivative of those used by the Gemini astronauts, the suit has been adopted for use by the Space Shuttle crews. Although the suit is rather cumbersome, the short ride to the aircraft is fairly comfortable, as the PSD van has large reclining seats and portable air conditioners for suit ventilation and cooling.

Once you were in the cockpit, the PSD specialists completed their final environmental and life-support systems checks. Engine start, ground checks, and taxi-out for your "on-the-hack" takeoff went smoothly, and you're now level at FL250 on the way to the tanker for the usual "top off" prior to the first supersonic leg of the mission.

After 16 years of operational service, the SR-71 still remains the fastest and highest flying air-breathing aircraft in the world. It is not only capable of sustained speeds and altitudes in excess of Mach 3 and 80,000 feet, it routinely performs its mission of strategic reconnaissance in that regime. Over the years, the SR-71 has

earned a high degree of credibility in successfully accomplishing high altitude aerial reconnaissance. The highest levels of national command have long recognized the value of the SR-71 as a flexible, responsive strategic reconnaissance platform. The sole unit flying the SR-71, the 1st Strategic Reconnaissance Squadron (1SRS), a part of the 9th Strategic Reconnaissance Wing, is located at Beale AFB in northern California. Most of the squadron's operational missions are flown from forward detachments in overseas areas. The small number of 1SRS aircrews, each consisting of a pilot and reconnaissance systems officer, spend much of their time TDY flying actual operational missions in support of the nation's peacetime strategic intelligence requirements. The intelligence information resulting from these missions is critical to the national defense posture, and no supplemental motivation is needed for the crews to "get the job done."

The role of the RSO bears little similarity to the traditional duties of earlier airborne navigators and the navigation usually is taken care of by the "black boxes." For the SR-71, that's the Astro-Inertial Navigation System, or ANS. The ANS consists of an inertial platform coupled with an exceptionally effective astro-tracker capable of tracking multiple stars even in bright daylight. When tied in with the multi-function navigation computer, a remarkably reliable and versatile system results. It is electronically connected to the autopilot, and can provide an auto nav capability. In this mode, the aircraft will maintain an extremely precise ground track at the normal operating speeds and altitudes of the SR-71. The ANS is loaded prior to each flight with a computer tape cut specifically for that mission. The tape provides for automatic navigation, sensor operation, and fixing information throughout the flight. The RSO also can steer the aircraft through computer inputs, as well as read out virtually any flight parameter he desires, such as true airspeed, groundspeed, altitude, crosstrack, time-to-go, etc.

With the ANS doing the busy work of navigation, the RSO's remaining duties can be equated with the combined responsibilities of a copilot, flight engineer, and electronic warfare officer. As the checklist manager, he is responsible for the overall mission pacing from engine start to shutdown. Besides monitoring the aircraft's flight parameters, handling most communications, and keeping track of fuel consumption and cg, he operates the electronic defensive systems as well as the various sensor systems. Perhaps I should say that the RSO *monitors* rather than *operates* the defensive and sensor systems. Most of these functions are automatic, although each system and subsystem provides for manual backup operations by the RSO if the automatic functions fail. However, monitoring system activation while performing other duties keeps the RSO very busy at the pace of a mile every two seconds. The idea is to free the front seater from as many distractions as possible, since he has more than enough monitoring to do. This becomes especially true during abnormal situations, when the SR-71's thick checklist is quite a challenge.

Let's get back to the operational mission we took off on a few minutes ago—you were leveled at FL250 on your way to the tanker. Although heading for a tanker immediately after takeoff may seem unusual, normal operations for the SR-71 provide for air refueling shortly after takeoff to "top off" tanks for the supersonic portion of the mission.

Approaching the final phase of the rendezvous, the pace picks up again. The rendezvous is accomplished in radio silence, as is virtually the entire mission. Since the aircraft is not equipped with a forward-looking radar, the RSO uses bearing and distance information from the ARC-50 UHF/ADF radio to direct the pilot to the tanker. This equipment provides high power, jam-resistant, discreet communications and electronic range information between the tanker and the

SR-71. Once the join-up is achieved, the RSO and tanker copilot manage the fuel transfer, with the RSO paying particular attention to aircraft cg and onload pacing. During the refueling, the RSO must time the transfer of fuel so as to "pressure off" the boom at precisely the end AR point to maximize the amount of fuel for the upcoming supersonic leg. Once the air refueling is complete and you've accomplished the post-AR checklists, it's time to transition to an entirely different and unconventional phase of flight.

"Throttles Mid A/B" is the first step you read to the pilot as you prepare to enter the transonic portion of the climb and accelerate to cruise speed and altitude. Using the "dipsy" maneuver—an initial climb with the throttles set to maximum afterburner, followed by a slight pushover to minimize drag and fuel consumption—you slip through the Mach smoothly and quietly (quiet from inside the cockpit, at least). From this point on, you and your pilot follow a carefully orchestrated procedure as the engine inlet systems transform the two Pratt & Whitney J-58s from nearly conventional turbojets into nearly pure ramjets. The result is a steady increase in Mach number as you continue to climb to cruise altitude. This can be one of the more critical phases of flight, particularly if the air inlet computers don't maintain the supersonic shock wave precisely within the inlet. This is absolutely essential in order to slow down engine air to subsonic speeds. The result of an aerodynamic disturbance in which the shock wave is expelled from the inlet, commonly called an unstart, can be spectacular. Depending upon the Mach/KEAS (Knots Equivalent Airspeed) relationship at the time of the unstart, the airframe can be subjected to sudden, rapid, and violent pitch, roll, and yaw forces due to the instantaneous increase in drag and resultant thrust asymmetry. Some crew members have experienced unstarts in which these transient forces have been strong enough to dash their helmets from side to side against the canopy. However, the inlet computers are programmed to recover rapidly from an unstart condition by automatically repositioning the inlet spikes and bypass doors to recapture the shock wave and continue with the proper inlet schedule. If the computer fails to clear the unstart, the crew can override the automatic system and manually schedule the inlet controls to the required positions. The pilot and RSO spend many hours in the SR-71 simulator practicing for just such an eventuality.

You're now approaching the supersonic level-off point, as the front seater pulls the throttles back to the minimum afterburner range to stabilize at the programmed Mach number, which is 3.0 for this mission. The aircraft flies at speeds in excess of Mach 3, although its exact operational speeds and altitude capabilities are still classified. Interestingly, when operating in areas of the world where ambient air temperatures are relatively cold, the airplane tends to accelerate and climb past Mach 3 even with the throttles backed up right against the minimum A/B stops.

Since the SR-71 covers substantial ground quickly, getting to the mission area doesn't take long in most operational missions. Staying ahead of the airplane, a basic premise drilled into every UNT student, is even more critical when cruising at 2,000 miles per hour. A rapid, effective crosscheck is a *must*. Although the ANS does an outstanding job of navigating, the old principles of DR still apply. At Mach 3 a few degrees of heading error for just a few minutes will get you way out of the ball park. Therefore, the RSO must continually take fixes to verify the accuracy of the nav computer. As you prepare to enter the mission area, you must recheck and preset the onboard defensive systems. As demonstrated by recent hostile actions against US aircraft in international airspace, the speed and altitude of the SR is no excuse for complacency, even during peacetime. One final check of the sensor systems before entering the area, and you're ready for the meat of the mission. Some of the most advanced areospace technology in the world went into getting you, your partner, and the aircraft to the target—but if the sensors malfunction, not much will have been gained by all that effort.

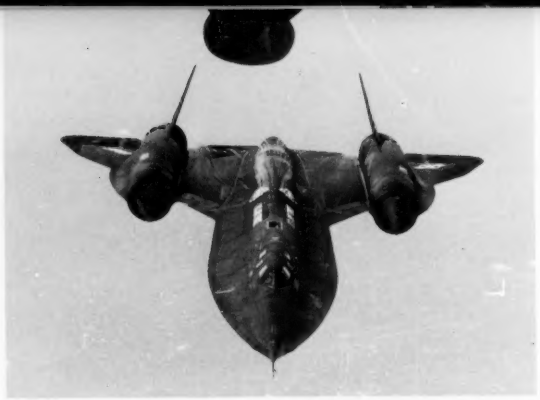
Fortunately, years of practical application and operational experience have proven that the SR-71's myriad of optical, radar, and electronic sensors are extremely reliable and effective.

Once the appropriate checks have been completed and you've begun the sensor action leg, the intensity of your crosscheck increases. Programmed sensors and systems are on and operating properly. Continue monitoring nav computer for accuracy—only zero crosstrack is acceptable. Watch defensive systems for proper operations. Monitor fuel consumption—temperature deviations at altitude can put you on the critical side of the fuel curve. Recompute emergency egress heading and distance to the best abort base should you encounter any problems. Monitor the HF net for specific mission information. Anticipating problems is necessary in any aircraft—the speed and altitude of the SR make this even more crucial.

The importance of crew coordination cannot be overemphasized and crew integrity is absolute from the start of training through your entire tour. On operational sorties such as this, the whole crew is replaced if one crew member cannot fly for any reason.

As you complete your mission objectives, you can't relax, particularly if you're programmed for a second supersonic leg. You may need a second air refueling which calls for a hot rendezvous—planning your timing and descent from altitude to hit the ARCP on time, again in complete radio silence. To make it work, you'll begin ranging with the tanker hundreds of miles from the ARCP and will generally start down about 200 nm out, after computing your start descent point based on current altitude and temperatures. An accurate descent profile is absolutely necessary to insure a successful rendezvous. As with the climb and acceleration a strict procedure must be followed, particularly in scheduling throttle settings to preclude compressor stalls and the likelihood of engine flameout. While going through the descent checklist, you continue to monitor range and bearing to the tanker, giving the pilot course corrections as necessary.

Due to the nature of the mission, we often find ourselves conducting air refueling operations in some out-of-the-way places. The 100th Air Refueling Wing at Beale AFB is home for the specially modified KC-135Q tankers supporting the SR-71 mission. The SR crews have complete confidence in the "Q" crews to be on station and on time in those out of the way places. The tanker crews appreciate the importance and high visibility of the SR-71 mission, and the SR crews, in turn, realize there would be no mission without



tanker support. Operational SR crew members say that one of the prettiest sights in the world is the tail end of a "Q" model as it rolls out in front of you on time and on track for a much needed AR in the middle of nowhere.

You've now leveled off subsonic again after completing your descent and are closing on the tanker for the second refueling. After the join-up is accomplished and the fuel is onloaded, you're ready to start the accel again and head for the next supersonic leg.

If this typical SR-71 mission profile interests you, you might want some information on getting into the program as an RSO.

BASIC REQUIREMENTS

RSO applicants must have a 15XX AFSC and at least 1,200 hours of jet time. The selection process favors captains and majors with Stan /Eval /instructor background, and experience in more than one aircraft. Entry requirements are listed in AFR 36-20, Chapter 8. Additionally, the 9SRW will answer inquiries concerning crew selection through their Replacement Training Branch. You can obtain detailed information about the program from 9SRW/DOTN.

Applications are evaluated by the 9SRW Applicant Review Panel held every 90 days or at the direction of the 9SRW/DO. After initial screening of applications, individuals selected will be invited to Beale AFB for a flight physical, simulator evaluation, and interviews with 1SRS and 9SRW staff. Since the flight physical is extensive, the flight surgeon's office will have the applicant's medical records pulled and screened prior to his arrival at Beale. They will be checking primarily for anything that might cause the applicant problems flying in a high altitude, pressure suit environment. The interview and physical take five duty days and are designed to evaluate the applicant's attitude, professional qualities, military bearing, personal motivation, flying ability, and physical qualifications. One day is devoted to simulator orientation and applicant evaluation by the SR-71 Stan/Eval Instructor RSO.

INITIAL QUALIFICATION TRAINING

If selected, the RSO will be paired with a pilot selectee upon arrival on station. They will then enter the Initial Qualification (IQ) training phase as a crew, and under normal circumstances will remain an integral crew throughout their tenure on the crew force.

After four to six weeks of intensive academic training, the crew begins the IQ simulator phase consisting of 100 to 120 hours in the SR-71 simulator. Upon successfully completing the IQ simulator check, the crew will begin flying the aircraft while simulaneously continuing with the Mission Qualification (MQ) phase of simulator training, consisting of about 20 to 25 hours. The MQ check is followed by 16 to 20 hours of Advanced Training (AT) in the simulator which is programmed to coincide with actual training missions flown in the SR-71 A. After completing IQ, MQ, and AT simulators, and accumulating 100 hours in the SR-71, the crew is given a final evaluation and certified operational. The entire process averages from 10 to 11½ months. Needless to say, these will be some of the most challenging and rewarding months of the aspiring RSO's career.

Perhaps the most satisfying aspect of the SR-71 mission is knowing that every ops sortie you fly adds important data upon which command decisions affecting the national interest are made. If you talk to any crew member about the airplane and the mission, you're sure to find the same high level of enthusiasm and esprit de corps. It just doesn't get old, and I've never met an SR-71 crew member who looked forward to leaving the job. As a matter of fact, the most common complaint you'll hear from the guys who fly this remarkable machine is "Where do you go from here?"

Maj Stampf obtained a degree in Aerospace Engineering from New York University in 1970 and later earned a master's degree in Management from Troy State University. He completed UNT at Mather in 1972 and was then assigned to the RF-4 at Shaw, Bergstrom and Alconbury AFBs. Since 1979, Maj Stampf has been assigned to Beale AFB with the SR-71 program.

An interview with Major General Hall

Recently the Editor interviewed Major General Titus C. Hall, Commander of the Lowry Technical Training Center, Lowry AFB, Colorado. General Hall was commissioned through the ROTC program in 1952, and earned his navigator wings at Ellington AFB, Texas. General Hall served as a B-47 navigator and in subsequent assignments has held numerous command and staff jobs with Systems and Logistics Commands. Immediately before his present assignment at Lowry, General Hall was Deputy for Reconnaissance and Electronic Warfare Systems, Headquarters Aeronautical Systems Division, Air Force Systems Command.

THE NAVIGATOR: From time to time we hear that navigation as we know it is a dying art, and navigators face a limited future—as far as jobs, careers and weapons systems. Based on your experience as a nav and your involvement in aircraft development, what do you foresee in the years ahead?

GENERAL HALL: Well, I believe that the future for navigators is especially bright, in many ways. For example, the workload in fighter-type aircraft is such that two-seater aircraft will be used (such as the F/EF-111 and F/RF-4) for the foreseeable future. If a two-seat F-15 is generated in the near future, systems operators certainly will be needed. You will continue to see navigators in both fighters and bombers. For example, the EF-111 is just now coming into the inventory, and that was one of the systems under my management on my previous tour with Systems Command. Now, for those navigators who time wise are beyond flying in the aircraft, and for those who have met their flying gates, I believe they are the best qualified people in the Air Force to get into Systems Command to help develop the aircraft of the future. They have firsthand knowledge and experience with the various radars, computers, etc., in modern aircraft. Navigators will be very highly sought after to work with the new aircraft.

Many navs agree with you; however, many are unable to get out of the cockpit into other jobs because of the current shortfall in rated slots. How can one best prepare for such supplement duty?

Of course, the cockpits must be filled and some people will have to continue to fly. However, those navigators who prepare themselves with the appropriate education—such as an engineering degree followed up with a systems engineering management degree, financial management degree or business management degree—will be sought as having the prerequisites for a job in systems development.

You started your flying career in B-47s with SAC. That must have been quite a job, for the nav was very busy during the entire mission with

precomps, navigation, bombing, etc. How did that background prepare you for the important command jobs you've had during your career?

I loved my job in B-47s. You didn't fly the B-47, you lived the B-47. That experience has helped me in my various jobs by providing the driving need and stress tolerance level required to work very tough jobs. The B-47 was a very sophisticated airplane and required three people to work as a team. I discovered the teamwork required to do such a job. That has translated directly into all my other jobs. For example, at present I work with some 50 commanders and it takes a great deal of teamwork to accomplish this mission at Lowry. Through good teamwork, you can put a sharp edge on whatever you've doing, and then the activity is much more productive for the Air Force. My B-47 experience taught me that as you work through your mission, you have a high feeling of elation and mission accomplishment as you complete various phases of the mission. You learn to get a handle on things, and do many things simultaneously. You also learn that you're bound to make mistakes from time to time. There is nothing wrong with that, and you must realize that you will fail in certain areas occasionally. Use the lessons learned from a mistake or failure to go ahead and do greater things.

How did the crew discipline and orderliness you learned as a nav come into play in your flying days and subsequent assignments?

I learned to have a plan B ready to go. For example, in celestial precomps you should have a backup plan to shoot stars at different times or shoot different stars if something unexpected occurs. You must have a plan and alternate plans to be prepared for all occasions, and this certainly has been a key in my jobs after the B-47. You must decide how much energy you want to put into a backup plan, no matter what you're involved with.

I'm sure our readers are interested in your present job. Many flyers aren't very familiar with some of the Air Force's support functions and you certainly have one of the largest training bases in the service. I believe you process around 6,000 students a week through here.

That's right. I am the Lowry Technical Training Center Commander, and we have a number of tenants on the base. The primary training

mission is accomplished here, and it's a very exciting mission. This year, some 36,000 students will complete over 450 courses. We have 16,000 permanent party people on the base. In 1980, we graduated 25,000 students. In 1981, we graduated 31,000 and this year, 1982, we are projected to graduate 36,000. We teach in the areas of munitions, avionics, audio-visual, intelligence, and logistics. We also have a Correction and Rehabilitation Squadron, which is unique in the Air Force. Our job here is extremely important to the Air Force. For example, we train the technicians to use the munitions and avionics for, say, the FB-111 F-15, F-16, A-10, and F-4. Many of our students come directly from basic training, and when they leave here they go straight to operational units, so we must take basically an untrained person and produce a usable, valuable resource for the major air commands.

As the commander of such a vast establishment, obviously you can't be intimately involved with every aspect of the entire base. How do you stay informed and updated on the events here, and how involved do you get with the thousands of folks stationed here?

Maybe you can't meet everyone, but you can certainly make your presence felt, and you do that in various ways. Here's an example of what can happen. Many of our classes are 6 to 8 weeks and some stretch out to 9 months or so. There are times when I go down to Lackland, and while the students are still in basic training, or preparing to come here, I talk with them. On two occasions, we've gone down and flown back from San Antonio with the students. The first time, I just put on civilian clothes and chatted with them on the plane. About 30 minutes out, I put on my uniform and to their surprise, they found out that I was the commander here. The students really did a beautiful job representing themselves and the Air Force, and I continue to be amazed and proud of how young people transition from civilian life to the Air Force family. On weekends my wife and I go to the Airmen's Club and talk with them, and I also go over to the dormitory, where we can talk to them on their own grounds. In fact, we get some of our best information on how the base is doing its job by talking to our young airmen in the laundry room and dining hall!

One of the things frequently discussed today is navigators commanding flying units. What do you see in the future for this, and is the picture bright?

We have progressed in the area of command as General Allen and General Mathis promised. I think we will continue to improve our number of navigator commanders as we consistently demonstrate operational performance and people management capabilities. We will get flying unit command jobs because we are the best qualified for the job and not solely because a navigator unit commander quota must be filled. We must compete and win. The basic question seems to ask, "Can a navigator manage a flying unit?" Yes!! I know a navigator is completely capable of making the kinds of decisions that a flying command requires. Any commander relies on the advice and expertise of his various area specialists. You've got to understand people, as well as operational management. I was the 2750th Air Base Wing Commander at Wright-Patterson — we successfully managed a large number of diversified aircraft movements on a daily basis. I never had problems because of my nav background.

You stated at the 1980 Navigator Symposium that the most difficult job of your career was being Base Commander at Wright-Patterson. Could you elaborate?

Well, at that time we had 26,000 people on the base, 32 generals, and some 60 tenants. Covering all of these was a lot of work but it was very, very interesting. Now I've found another challenge—this job. I greatly enjoy the young people here and all the aspects of the systems, logistics, and so forth. The toughest part of this job is managing the Correctional and Rehabilitation Squadron, being responsible for the folks from Leavenworth and Fort Reilly, and then making decisions as to their eventual fate.

What are some of the traits that all good commanders have in common?

First, a good commander must realize that he is about 15th or 20th in the list of priorities he sets for himself. He must understand his mission, and then he has to provide for all of the people in his command. He has to remember that his people are human and have problems. In addition to helping

solve the problems, he must do a great deal of listening and sometimes folks solve their own problems. Listening to your people is very, very important. As far as priorities, the first priority in anything is God—so we work within His concepts of what life should be—then the next is America, followed by the Air Force, then your particular organization, people on base, family, and so on. The point is that the commander must put many things and people before his own desires. The number one thing a commander must do is complete his mission—and number two is to make sure his people are taken care of so they can do the mission. Incidentally, many times, for a commander, there are no hands on the clock—when something needs to be done, you work until the job is finished. Command is putting your people in the frame of mind so that they are not doing just what they're told, but innovatively doing whatever they can to make a better Air Force.

What advice can you give our new readers just beginning their Air Force career?

I use an acronym called LISTEN. ***L*** means people should be loyal to God, country, the Air Force, and to themselves. ***I*** stands for the highest integrity; when you sign your name to a piece of paper, it means that it is the best you can do with your ability and the resources available. ***I*** also means innovative; always have plan B, and a vocabulary with no such thing as "can't do." ***S*** stands for serious about our national security, for that has kept us free for over 200 years. Let the ***T*** mean the technology that has kept the Air Force in the forefront, and we must continue to be on the leading edge of technology to be the greatest Air Force in the world. ***E*** means to be hungry for education, both academic and PME. And, finally, the ***N*** stands for right Now; Now is the time to put it all together to be the best military person possible. In addition, always do more than is required. For example, aim at 30 to 40% above the standard. Then if you miss a little of your own personal goal, you are still 20% or so above the standard. Always strive for excellence—never do the minimum just to meet the standard, whatever the job. Always be honest and sincere, and "tell it like it is." You'll be respected for that.

What past events have enabled you to have such a successful career?

You must press to exceed the standard by significant amounts in tough areas. If your attitude is good and people know that you're trying, you will be recognized. You've got to have the right attitude—a good, positive outlook on things, and that will atone for some of the errors that you're going to make. When others know that you have the right stuff and you're aiming at the top, this will make all the difference in the world.

What's your opinion of the new officer and enlisted folks presently entering the Air Force?

The quality of our new people is good, and I'm so proud that the young people we're getting are serious about the flag, the country, and the Air Force. There seems to be a great resurgence in the country about the military. In addition, the governmental leaders are interested in a strong defense. It's up to us right now, for we have this great swell of Congress and the public behind the Air Force. We must put out good systems, train our people in the best manner possible, and be sure that our personal images are such that everybody, including any potential aggressor, knows that our country will stay free, because we have people with the right stuff in them.

Thank you very much, sir, and the best of luck to you.

NAVIGATORS FOR THE 80'S IN THE RAF

Wing Commander P.H. EUSTACE
RAF Finningley

THE EVOLUTION OF THE NAVIGATOR'S ROLE

The role of the navigator could be said to have gone full circle since he first appeared as an observer in the early days of aerial combat in World War I. In those early days the observer was an integral part of a two-man crew involved primarily in low-level visual reconnaissance. Today, and for the rest of this century, a large proportion of the Navigation Branch will be concentrated in the two-seat low-level environment in the back seat of Tornado. In the intervening years the evolution of the navigator's role was dictated by the type of aircraft in service and the role and environment in which those aircraft were employed. For example, during World War II air defense was primarily day/VMC only and very much the "dog fight," close range type of battle and, while an extra pair of eyes would have been an advantage, the extra fuel and/or reduced weight made the single-seat fighter the most suitable to meet the demands of the prevailing situation. However, the demands of flying night bomber raids deep into German territory with very limited navigation aids made the lack of a navigator in the crew a virtual 'no-go' item. Since WWII the traditional type of navigation has prevailed through the expansion and dominance of the transport fleet to meet the nation's world-wide commitments. In addition, both the high-level strategic role of the 'V' force and the limited aids, miles from anywhere over-the-sea requirements of Coastal Command also demanded high levels of navigational skill, but not specifically airmanship or aggressiveness.

Why then has the situation changed so dramatically over the last ten years? There are, I believe, three main reasons. First, the reduction of the nation's overseas military commitments to a point where virtually all of its efforts are committed to the European theater with its varied terrain and often poor and unpredictable weather. Secondly, the introduction of the 'flexible response' policy in Europe, and associated with that, the third reason is that if our aircraft are to survive over Warsaw Pact defended territory then they must fly below 500 ft AGL. Thus, virtually

overnight, it became necessary to change the shape and inventory of the Royal Air Force to what is now, primarily, a tactical air force. Furthermore, it also had to be an all-weather, day/night air force capable of carrying out its tasks in a hostile environment almost certainly without air superiority. It was to meet these requirements that we had such two-seat aircraft as the ill-fated TSR2 and, for the RAF, its equally ill-fated replacement, the F-111. What we ended up with were the Buccaneer S Mk 2B and the McDonnell Phantom. Having introduced both of these aircraft into service it soon became obvious that the demands of flying them in the low-level European environment were such that any tasks that could be reassigned from front to back seat, and thus reduce the pilot's workload, would enable the crew to operate the aircraft much more effectively and, in peacetime, much more safely. In essence, it allowed the pilot that much more time to keep his eyes outside the cockpit. In addition, it also meant that the aircraft could still be operated in poor weather or at night, or in what was likely to be a very heavy and restrictive electronic warfare (EW) environment. Thus, many navigators had very quickly moved away from a 'traditional' position-finding role to one embracing any combination of the following: weapons system operator, tactician, fightergator in air combat situations, electronic warfare operator, directional consultant, radar operator, the 'eyes' of the formation, target designator, airborne missile controller or the 'conscience' in the cockpit. The results of such exercises as Tactical Fighter Meets, Tactical Bombing Competitions, Red Flag and Maple Flag clearly demonstrated the value of the 'tactical' navigator and the two-man concept.

Turning to specific roles for the navigator in the new generation of aircraft, the man in the back seat of Tornado is likely to find his priorities somewhat different from the 'urgonomic slum' of the Buccaneer. Most of his previous manual labor, such as positional information, routing, 'raw' radar scope interpretation and weapons delivery, will be carried out by the computer. He should, if the designers have it right, be able to spend much more time in analytically assessing the quality of information rather than relying as he does at present on 'experience.' The aircraft will have a far greater all-weather day/night capability, with its terrain-following radar, but such systems need to be analyzed critically and cross checked regularly for accuracy. Target identification remains a problem, be it air-to-air, air-to-surface or air-to-ground and sensors such as forward looking infrared radar (FLIR), designed to improve the range at which targets can be identified and acquired, will become the responsibility of the navigator. Likewise, both active and passive electronic warfare equipment, data link communications, missile acquisition, launch and control, and the ever important visual lookout, will remain areas of prime responsibility for the navigator. The overall effectiveness of Tornado will rely very heavily on the tactical awareness of the navigator and on his management of the aircraft's navigational, weapons and tactical systems and sensors.

Looking ahead to the 1990s the one aircraft project of the future that appears not to include a navigator is the Harrier/Jaguar replacement. At present, the basic design envisages single-seat operations presumably to overcome the cost, weight and aircraft system complexity problems associated with two-seat design. Aircraft manufacturers, constrained by cost, justify the single-seat option by introducing into the pilot's cockpit sophisticated digital and electro-optical systems designed to ease the pilot's workload. What happens in practice is that a new form of workload is generated; that of monitoring the performance of these equipments. Systems like low-light television (LLTV) and FLIR undoubtedly have the potential to improve the effectiveness of aircraft at low-level. However, trials have shown quite clearly that the pilot needs to devote all of this concentration to avoiding the ground and obstacles, to the detriment of other tasks. The problems of single-seat, low-level operations with a high cockpit workload are well known as is the fact that when the workload does become too high, the experienced pilot reverts to the traditional techniques used in the heydays of the 1960s and 1970s and the advantages offered by the advanced systems are lost. The main danger at

the moment is that we may replace Harriers and Jaguars with a 1990s Hunter. While many pilots would welcome this, it would not meet the requirements of the likely operating environment. If the objective of offensive operations is to achieve the highest probability of weapon delivery success from a relatively small force then a second seat is needed. Moreover, if the final design is to have an air superiority role as well, then the inclusion of a navigator is essential. The more honest F-15 pilots operating in Europe admit that while being happy to fight singlehanded above 5000 ft, when below and close to the ground, they would be both happier and more effective with a 'fightergator' in the cockpit to assist.

The navigator has come a long way since those early days of the First World War. There is little doubt that the success of the RAF's new generation of computer-based weapons systems will rely very heavily on the navigator's tactical awareness, flexibility, ingenuity and ability to control a situation decisively and effectively. The success of the Nimrod MR and Shackleton AEW, often in competition with more sophisticated aircraft systems, has in no small way been due to the skill and innovative spirit of their navigators. The overall effectiveness of the two-man crew, particularly in the European theatre, is beyond dispute. Moreover, any serious discussion on the replacement/s for the Harrier and the Jaguar must take into account the inherent value and effectiveness of the tactical navigator. The success of the Buccaneer and the Phantom has convinced other nations, such as West Germany and Italy, that a dedicated role-trained navigator makes a far better 'fightergator' than would an inappropriately trained and poorly motivated 'second pilot.' Nevertheless, the challenge for the navigator as an aviator in the 1980s is unprecedented.

This challenge and its requirements have been recognized and the 1980 navigator syllabus was designed, after close consultation with the operational conversion units, to be much more operationally orientated. It aims to develop the student's levels of airmanship, self confidence and strength of personality and character. Furthermore, the navigator is now trained to 'talk' to the computer and use it as a tool of his trade, while retaining a depth of basic navigation skill with which to revert to 'manual' when system malfunction or battle damage render it the only remaining option.

What is less certain is whether full use will be made at squadron level and above of the skills developed by the navigator as a supervisor and commander. There have been navigator captains, executives and squadron commanders in the Nimrod and Shackelton forces for some time, and recently, navigators have become squadron commanders in both the Buccanneer and Phantom forces. Furthermore, there has been one navigator station commander of an operational fast-jet base. In all these cases the navigators concerned have met with considerable success because they were selected, albeit perhaps in some cases reluctantly, because they were the best men for the job. The difference in the RAF's attitude to navigators in senior squadron and station executive appointments to that of other NATO nations is profound. The recognition by the RAF of the value of the navigator has been earned. However, if this belief in full employability for the navigator is to remain credible, a continuance of that faith should be forthcoming by the appointment of a navigator as a Tornado squadron or station commander early in the reequipment program.

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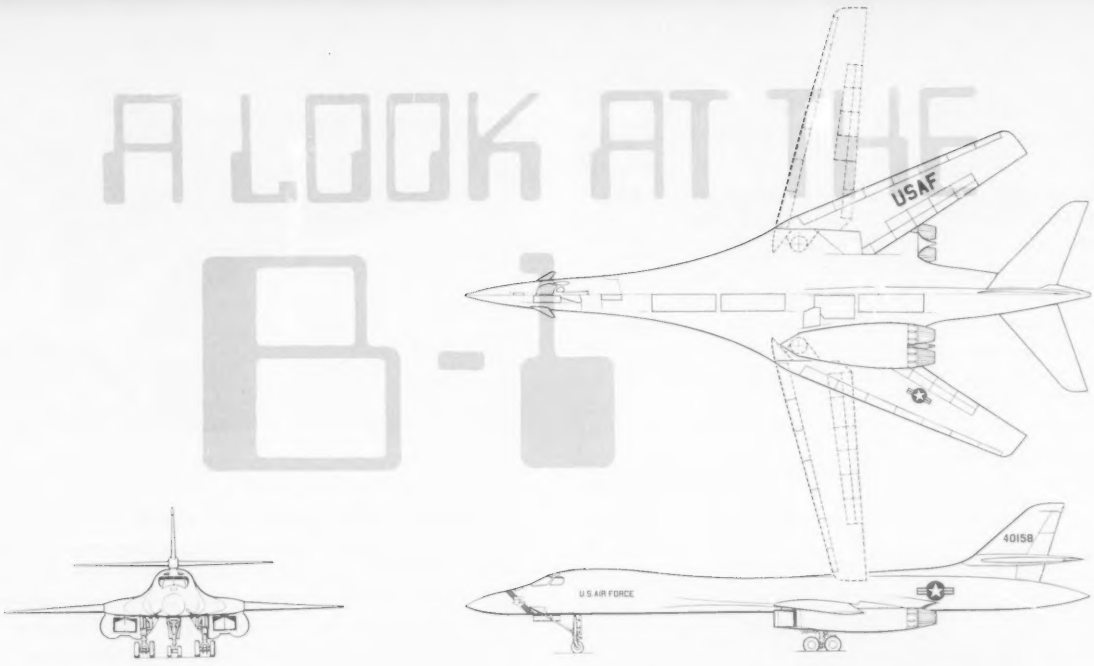
A LOOK AT THE B-1



WASHINGTON (AFNS)—The President has authorized development of the B-1B long-range combat aircraft. Based on the original B-1 design, the aircraft will have a larger payload and improved penetration capability.

Air Force officials say the B-1B will take over the penetration role from the increasingly vulnerable B-52, and continue that task after an advanced-technology bomber is deployed. The B-1B will be able to carry cruise missiles and conduct a variety of missions during its estimated 30-year life. It will complement the advanced-technology bomber and contribute to conventional and strategic missions well into the next century.

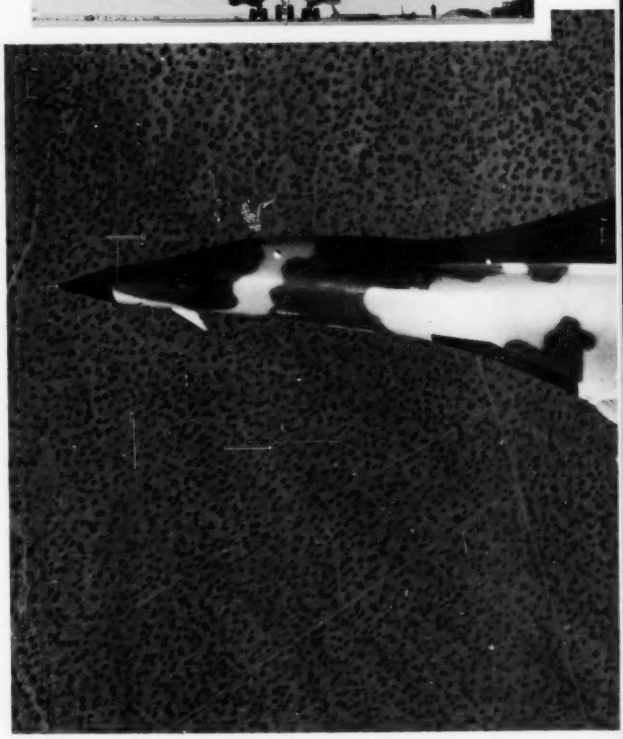
The first of 100 B-1B s could be delivered to the Strategic Air Command in mid-1986.

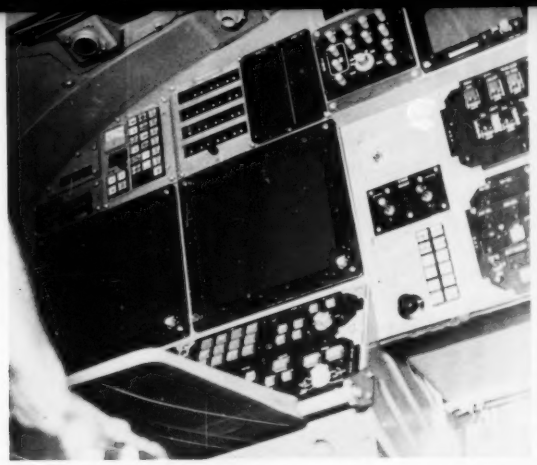
Two of the original four B-1 bombers will be used for B-1B testing. Modification to the first will begin in 1982, with flight testing scheduled to begin in 1983. Flights with the second test aircraft will follow.

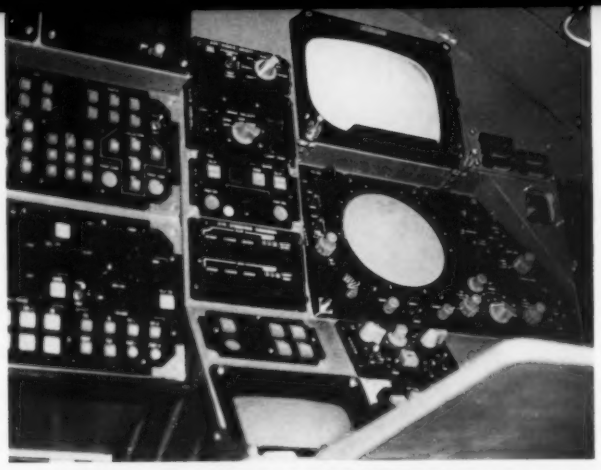
The first modified B-1 will be used for weapons and separations tests. The second will be used for avionics development. It will also undergo engineering and fabrication modifications throughout flight testing.

Major changes to the B-1 include:

- Off-the-shelf FB-111A avionics currently in the B-1 aircraft will be replaced with the modern offensive avionics system developed to update the B-52 aircraft.







- Structural changes will permit increasing gross-takeoff weight from 395,000 pounds to 477,000 pounds, external and internal carriage of air-launched cruise missiles, addition of radar-absorbing material and use of ejection seats instead of an ejection capsule.

- Engine inlets will be changed to optimize the B-1B's high subsonic, low-altitude penetration mission.

- A terrain-following radar will allow the B-1B to follow the "nap of the earth" at near supersonic speeds, thus cluttering a watching enemy's radar screen with hills, trees, mountains and towers and making it difficult to track the aircraft. High-speed, low-altitude flying also reduces the possibility of interception by enemy aircraft.

The B-1B will also be equipped with electronic jamming equipment, infrared countermeasures, radar location and warning systems and other devices to defeat enemy defensive systems.

Managing the B-1B for the Air Force is the Aeronautical Systems Division, Wright-Patterson AFB, Ohio. Prime contractor is Rockwell International Corp. Testing will come under the direction of the B-1 combined task force at Edwards AFB, Calif.

ELECTRONIC WARFARE TRAINING AT MATHER

Captain Patrick REYNOLDS
453 FTS
Mather AFB, CA

The 453d Flying Training Squadron (FTS) at Mather AFB provides Electronic Warfare (EW) training to USAF navigators and US allied military personnel qualified to perform EW duties. Eight continuing courses meet the needs of the USAF major commands, other US services, and allied nations. The 453 FTS, a part of Air Training Command (ATC), gathers and presents required information, enabling the graduates to perform to a set standard.

The Air Force began EW operations at Boca Raton AFB, Florida in January 1943. The course was titled Radio Officer "C." The Strategic Air Command (SAC) started a school in 1949 at McGuire AFB, New Jersey to build up their initial small cadre of 20 officers, using B-29s as flying classrooms. This school moved to Barksdale AFB, Louisiana in late 1949. Shortly thereafter, ATC became responsible for the six-month electronic countermeasures (ECM) training course, and the SAC school was transferred to Keesler AFB.

The Keesler program moved to Mather in January 1962. Designated the 3537th Electronic Warfare Training Squadron, this new group identified with the "Chessboard" emblem signifying the reactive nature of EW. In 1966, the ET-29D entered service at Mather and became the flying classroom for real time reconnaissance and ECM training until replaced by simuators in June 1974.

In July 1972, the Squadron was redesignated the 453 FTS under a plan to link all training squadrons with former units of proven distinction. The 453d has a flight-bomber combat history, flying such diverse aircraft as the B-26, F-86, and F-100. With this new designation came the squadron's traditional Tiger emblem used today. The formal activation took place in March 1973.

ATC provides general guidelines on how and what we teach. Of course, the Air Staff is the primary source of Air Force EW training policy. Periodically, the MAJCOMs confer to reevaluate the Course Training Standards (CTS). A working level conference is held before the CTS conference to consider proposed changes, and once these proposals are determined, the 453 FTS initiates the changes in coordination with higher headquarters. Final arrangements and agreements are then reached at the CTS. The results of an October 1981 meeting will introduce the FY 83 program. The CTS is a flexible agreement which maintains the quality of our training.

Through the CTS process, course objectives are mutually agreed upon. These objectives are built by determining a behavior, condition, and standard. Each phase of instruction is composed of units containing one or more objectives. The lessons are taught by lecture, discussion, demonstration/performance, simulators, and tests. By these methods, the instructor develops a student-centered approach. After each phase, student critiques highlight trends and/or deficiencies and introduce suggestions.

When an EWO graduates from the 453d, he goes on to mission specific training at a Combat Crew Training School (CCTS) or Replacement Training Unit (RTU). By teaching the current MAJCOM

procedures in greater depth, these units make a weapon system specialist from a broadly trained individual. After six months of operational duty, the crew member receives another evaluation form, which helps determine how well the training matches the 'real world' environment. By receiving such feedback, the 453 FTS improves course development.

Each course has a phase specialist (PS) responsible for effecting changes to his units of instruction. The PS can implement any changes that don't effect the course hours, objectives, or add new information. If problems arise, the PS is assisted by the Phase Manager. All courses are monitored by a Phase Manager to insure that they comply with the CTS.

The 453 FTS uses a variety of talented instructors from every Air Force weapon system employing an EWO. Presently, 58 instructors, 5 computer programmers, and 12 administrative personnel are assigned to the squadron. These instructors bring expertise from the RC-135, B-52, EB-57, EB-66, B-58, F-105G, F-4C/D/E/G, F-111, AC-130, and MC-130. Each instructor attends a three-month Instructor Training School (ITS) before assuming instructor duties. The academic phase hones platform teaching skills in speaking, questioning techniques, and preparing lessons.

The 60-1 phase qualifies the instructor in the T-43A flying navigation classroom. All EW instructors accrue gate time (flying credit) while flying as navigators on UNT missions at Mather.

The 60-2 phase qualifies each intructor to teach specific units in one or more courses plus one of the simulators (T4 or T5). The Air Force commitment resulting from completing ITS is three years concurrent with a normal four-year controlled tour. Upon ITS completion, the instructor receives a T1575Z Air Force Speciality Code as a fully qualified instructor.

In FY80, the 453 FTS produced over 500 graduates in eight courses at a cost of $7.4 million. Approximately the same number of students will be trained in FY 81. This training breaks down into approximately 45% undergradute EW and 55% advanced EW education. The basic course supplies the Air Force with EWO manpower to replace separations, retirements, and expanding needs.

The advanced courses at Mather refresh and impart greater levels of knowledge to the flying and non-flying force. These courses broaden the students' scope on the latest capabilities and future trends in EW.

One of the Air Force's greatest challenges in recent years has been to keep experienced rated manpower in the service. The EW career field has not been exempt from this challenge, although recent developments indicate retention is improving. The total EW flying population in FY81 is shown by duty and aircraft in Figure 1.

FY 81 - EW Breakdown by Duty

879 - Operational
166 - In Training
689 - Staff (2275 AFSC)
158 - General Staff (2295 AFSC)
205 - Supplement, AFIT, PME

FY 81 - EW Breakdown by Weapon System

618 - Fighter
1,025 - Bomber
377 - Tanker
77 - MC-130, other

Figure 1

These figures reveal that 42% of these individuals are assigned to our front line fighting force and the rest to staff and rated supplement (a career broadening job pool).

It is no surprise that education costs increase every year. The EW career field has a limited budget, so we must use our training dollars wisely. Ending the flying program in favor of simulators was a step in this direction, as was shortening the basic course. We train each student in the reconnaissance, bomber, and fighter aspects on a systems level, which allows crosstraining of manpower at later dates.

THE BASIC COURSE

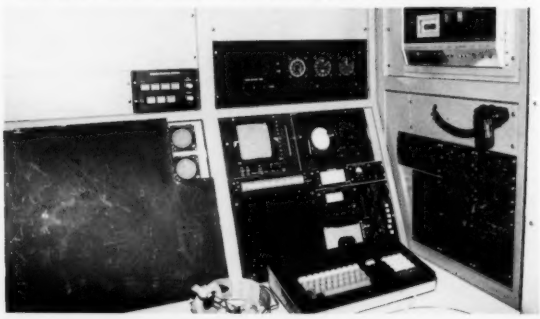
Every year, the 453 FTS graduates 14 classes with 15 students each. A new class enters every 18 duty days, and formal evaluations are required. All USAF EW selectees must be navigators on

current flying status in the active Air Force, Air Force Reserves, Air National Guard, or Marine Corps. Most students enter upon graduation from Undergradute Navigator Training, also conducted at Mather. The Marine Corps selects 5 to 10 of their Electronic Countermeasures Officer candidates per year to attend this course.

The syllabus consists of Basic Electronics, Radar Fundamentals, Integrated Air Defense Systems, Reconnaissance Systems, Basic Electronic Countermeasures, Penetration Systems, and Tactical Systems. Three programmed flying days allow students to maintain their currency as navigators in the T-37 or T-43A.

For the past two years, assignments of graduating officers have been: 44% - B-52, 16% - F-111, 30% - F-4, 6% - RC-135, 3% - EA-6B (Marines), 1% - Other (AC-130, MC-130).

The 453 FTS has two five-booth T4 simulators, each simulating a B-52H EW station. The T4s are used to teach bomber penetration tactics to entry level students. These simulators are updated constantly by SAC, and ATC usually receives the second prototype modification. In the 16 training day Penetration Systems phase, the students receive 43 hours of academic instruction and spend 10 three-hour periods in the T4 simulator. The greatest student benefit received in the T4 is individual instruction during every mission. Instructors monitor and critique problems as they occur. The final six missions are graded by the instructor to show student progress.



The T4 has an approximate 2000 x 2000 nm gaming area and 24 emitters can be displayed simultaneously. Emitter parameters come from various data bases, and SAC supplies the antenna scan patterns.

The T5 Simulator for Electronic Warfare Training is more affectionately known as HAL (from "2001: A Space Odyssey" fame). This student supplied nickname generally stems from its exacting grading criteria. The missions are computer graded, and two instructors monitor student progress. This simulator can run up to eight independent missions simultaneously (joint coordinated missions). The T5 has two computers which allow simultaneous mission execution and mission/software development. A future modification will acquaint officers with computer controlled reprogrammable EW systems. The new equipment to be installed is the ALQ-99E, ALR-62, ALQ-137, and computer assisted instruction (programmed text capability). The T5 has a 2000 x 2000 nm gaming area, up to 100,000 feet altitude capability, up to 2000 knots airspeed capability, and 63 simultaneous emitters. The T5 also uses source data for its emitters from the Foreign Technology Division, Electronic Warfare Integrated Reprogrammable data base tape.

Reconnaissance Systems employ the T5 for 24 hours of instruction in labs, missions, and an evaluation. Most of these reconnaissance missions are representative of those flown by the RC-135. Tactical Systems also uses the T5 to depict Wild Weasel missions flown by the F-105G. In the future, EW missions flown by tactical aircraft will be emphasized rather than Wild Weasel missions. Tactical Systems use the T5 for 22 hours of instruction in labs, missions, and an evaluation.

Without the T4 and T5 simulators, the 453 FTS could not perform the diverse training required by our users. The users range from commands directly employing EWOs in a cockpit to support commands desiring EW expertise on their staff. The biggest users are SAC and TAC. Electronic Security Command uses EW analysts and engineers in staff support roles. Military Airlift Command (MAC) employs a small number of EWs as staff consultants who make recommendations concerning EW for MAC's worldwide mission. Air Force Systems Command and Air Force Logistics Command need EW engineers to help design and field weapon

systems. Air Force Communications Command, Air Force Intelligence Service, Air Force Test and Evaluation Center, Tactical Air Warfare Center, Tactical Fighter Weapons Center, and the Air Force Electronic Warfare Center all employ a sizeable number of talented EWs to perform their missions. Support commands gain this necessary EW talent through staff officer positions and the Rated Supplement Program.

ADVANCED TRAINING

The 453 FTS provides continuing education to EW trained operators, commanders, and support personnnel. This mission requires three courses of advanced training: Electronic Warfare Refresher Training (EWRT), the Electronic Warfare Staff Officer (SO) Course, and the Senior Officer Electronic Combat (EC) Course.

The refresher course educates EWs with 4-5 years service on basic EW principles as well as the newest systems fielded by other commands. The 453d also uses EWRT to train non-EWs assigned in EW support positions. These attendees are computer programmers, engineers, logisticians, air defense controllers, intelligence analysts, program managers, and Air Staff officers. They come from the active forces, reserves, national guard, and other government services. EWRT is conducted 6 times per year with 15 students per class and no formal evaluations. Selected students present a 15-20 minute briefing on any current interesting projects. The overall intent of EWRT is to disseminate new information and to effect an interaction between class members of diverse backgrounds.

STAFF OFFICER COURSE

This course prepares officers and equivalent grade DOD civilians to serve in middle management EW staff positions. It addresses EW basics, then delves into the staff aspects of how the USAF employs EW. The 453 FTS holds 4 of these courses per year with 12 students per class. Graduates can more effectively use Air Force assets, and shorten the transition to staff duties.

SENIOR OFFICER ELECTRONIC COMBAT COURSE

Success in all conflict activity is increasingly dependent on correct decisions using the electro magnetic spectrum. This course helps this decision-making process by familiarizing senior commanders and managers with the fundamentals of EW, command, control, and communications countermeasures and suppression of enemy air defenses. Lieutenant colonel selectees and above, and equivalent grade DOD civilians with non-EW backgrounds, may attend.

The 453d holds 6 classes with 10 attendees per each year and no formal evaluations. The seminar forum of this class allows an excellent interchange of ideas among the participants, with the instructors presenting material and guiding the discussions. The overall impact makes these managers aware of the unique problems facing EC in areas they directly control.

TAC NAV TRAINING

This course prepares graduate navigation students for upgrade training as Weapon Systems Officers (WSOs) in tactical fighter, reconnaissance, and attack weapon systems. The 453 FTS instructs 36 hours of EW academics in this course. Subjects include basic electronic and radar principles, threat systems, radar warning receivers and signal recognition, ECM pods and expendables, and MIJI (Meaconing, Interference, Jamming, and Intrusion). This training prepares a WSO to employ EW equipment for self-protection of tactical aircraft. A portion of these WSO students continue at the 453 FTS for additional training in the basic EW program and become Electronic Warfare Officers.

The 453 FTS staff is constantly upgrading the quality of instruction by keeping in touch with the major commands as well as the Air Staff. The 453 FTS also attempts to have a close liaison with industry, by acting as the DOD sponsor for local symposiums and exhibitions at the annual Association of Old Crows (AOC) Technical Symposiums. Instuctor teams have conducted numerous briefing tours at Air Force and DOD agencies in the past two years, where mini-courses were taught to large organizational groups who otherwise would not be exposed to EW training.

Capt Reynolds received a degree in Electrical Engineering from the New Jersey Institute of Technology and was commissioned through ROTC in 1972. After UNT and EWOT, he was assigned to March AFB in 1974 in B-52s. Capt Reynolds has been assigned to Mather AFB as an EW instructor since 1978.

STAR IDENTIFICATION

PART III

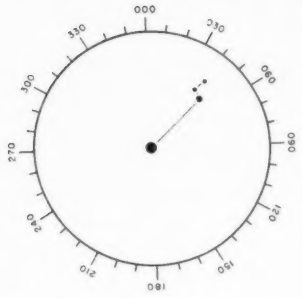
Part 3 of Star Identification includes the remaining 11 stars used in HO 249. The other stars are in Parts 1 and 2 of this article. (THE NAVIGATOR, Summer 1981 and Winter 1981).

Each chart presented shows the first, second, third, and fourth magnitude stars visible using a sextant with a 15° field of view. The desired star is shown in the center. On a clear night, many stars will be visible; on a hazy or moonlit night only the brightest will show. Lines were included to make the patterns more meaningful. Most of these follow the lines of the better known constellations.

The stars are shown as they would appear from the North Pole. For other latitudes, the accompanying table show how much the charts should be rotated for a correct presentation. Dashes indicate that the star is below the observer's horizon.

Enter the table with the nearest latitude and LHA of Aries to find the position angle. Then rotate the chart until this angle is at the top. The star pattern will resemble the one sighted in the sextant's field of view.

PROCYON



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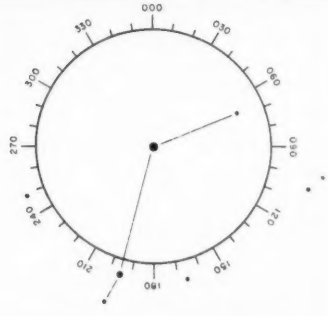
70N	-	020	017	009	358	347	341	340	-	-	-	-
60N	-	030	026	014	356	340	332	330	-	-	-	-
50N	-	040	036	021	355	332	321	320	-	-	-	-
40N	-	051	046	029	352	322	311	310	-	-	-	-
30N	-	060	058	040	348	310	301	-	-	-	-	-
20N	-	070	069	057	338	295	289	-	-	-	-	-
10N	-	081	082	079	304	279	278	-	-	-	-	-
0	-	090	094	103	225	262	267	-	-	-	-	-
10S	-	101	106	123	201	246	257	-	-	-	-	-
20S	-	110	118	139	193	233	246	-	-	-	-	-
30S	-	120	128	149	188	222	236	-	-	-	-	-
40S	-	130	138	157	186	212	226	-	-	-	-	-
50S	-	-	147	162	185	205	217	-	-	-	-	-
60S	-	-	155	168	183	198	208	-	-	-	-	-
70S	-	-	164	172	182	192	198	-	-	-	-	-
80S	-	-	172	176	182	186	-	-	-	-	-	-

RASALHAGUE



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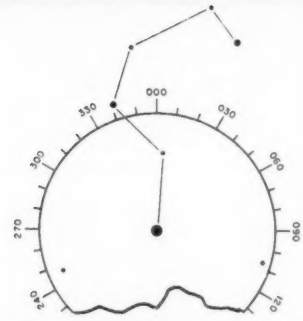

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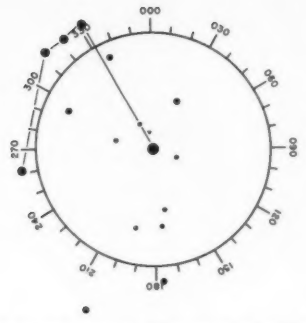
RIGEL



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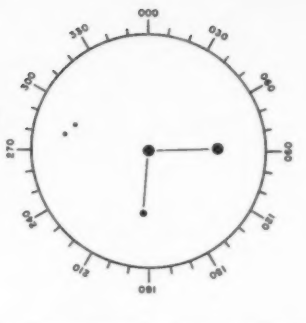
RIGIL KENTAURUS



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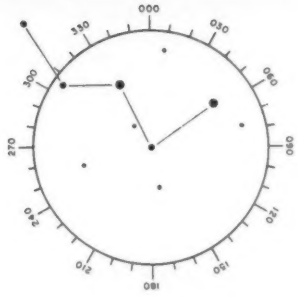
SCHEDAR



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60S	-	-	-	-	-	-	-	-	-	-	-	-
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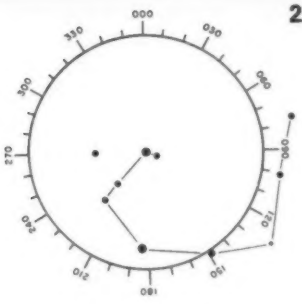

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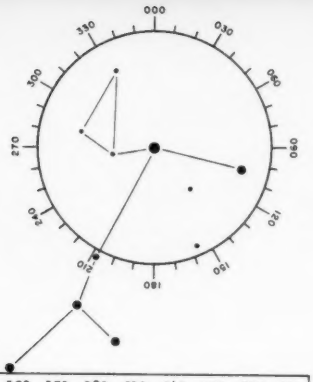

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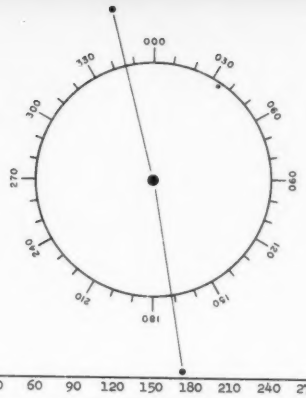

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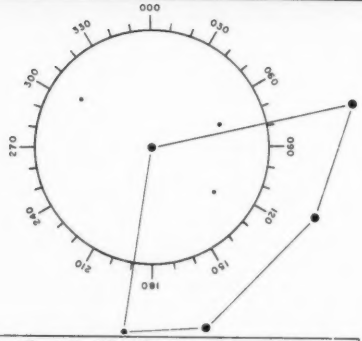
SUHAIL



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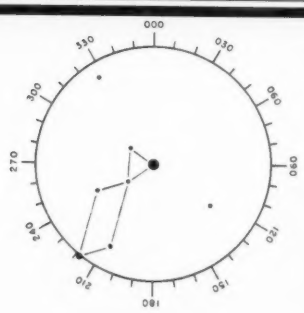
VEGA



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Mr. Darrell MADDOX
Hughes Aircraft Company
Culver City, CA

Paperwork is a pox on just about everybody's house—especially when it's crammed in the cockpit of a jet fighter. In these cramped quarters most navigators are forced to correlate what they see on the ground with the symbols and squiggles on charts. Not a safe or simple task in low-level flight in hostile airspace, over broken country, in bad weather or darkness.

Before this decade runs out, tactical aircrews should be able to permanently stow the paperwork, because experiments are currently underway that could make such unwieldy charts obsolete.

Then, instead of the usual head-bobbing exercise associated with relating a scene to the inscriptions on a paper chart, tomorrow's flier could watch moving imagery of ground targets and installations on a cockpit display that changes as the aircraft skims above the terrain. At the same time, continuously updated flight information would be superimposed over the "moving picture" map.

The map could be displayed as a look-down plan view of topographic information that is colorcoded for quick comprehension. Or, it could be presented in a three-dimensional, look-ahead perspective similar to the actual scene a low-flying aircrew is witnessing at the moment. It is updated as swiftly as the human eye can perceive, always ignoring bad weather, darkness or enemy jamming.

What makes such versatility possible is the magic of microelectronics, particularly the high-speed handling of digital data. The U.S. Defense Mapping Agency is translating conventional cartography into digital data—encoded in bits that a computer understands—to describe major natural and man-made features the world over. Digital data encompassing more than 250,000 square miles will be stored in the airborne electronic map's computer memeory.

Normally, such data would require a computer memory with several billions of data bits, complicating the storage and retrieval functions. But if only relevant data could be retrieved from this mass, computer access would be hastened appreciably. To simplify and expedite transformation of stored data into a displayed image, sophisticated data compression techniques are employed—sort of an algorithmic shorthand—to compact the stored data. This later can be expanded and amplified when retrieved and converted to full-blown imagery. The process can be likened to squeezing a wet sponge; when released and soaked, it again regains its original volume.

With data compression, electronic map designers are able to distill information on 35 acres of landscape into only 64 stored bits, the equivalent of four words on the computer. In fact, 400 million data bits stored in the computer memory contain all the information necessary to describe 250,000 square miles in great detail and with remarkably high resolution when displayed.

The map computer, constantly updated with navigational data, uses a predicted aircraft position to access and retrieve data from its memory as the plane skims over the terrain. This new data is then expanded to display an imaged replica of the landscape as often as 20 times per second.

Such high-speed processing promises a versatility far beyond the outer limits of moving map displays, today's most advanced aerial map systems. Moving map displays are filmstrips of sector maps projected on a cockpit display. However, content of the film is fixed.

In contrast, an electronic map system is much more flexible. It would be flexible enough to alter a mission plan to meet suddenly changing conditions. It could display terrain information in a number of different modes. Ultimately, it could provide terrain information to other subsystems to enhance their functions. On low-level attacks, for instance, the electronic map could be integrated with terrain following/avoidance and weapon delivery systems to increase their reliability. The electronic map also could add new features to existing sensor systems. Or its data could incorporate anti-aircraft threat avoidance data. Besides such in-flight applications, the electronic map has the potential to aid in pre-flight briefings. With it, a navigator could preview his planned flight route via video before takeoff.

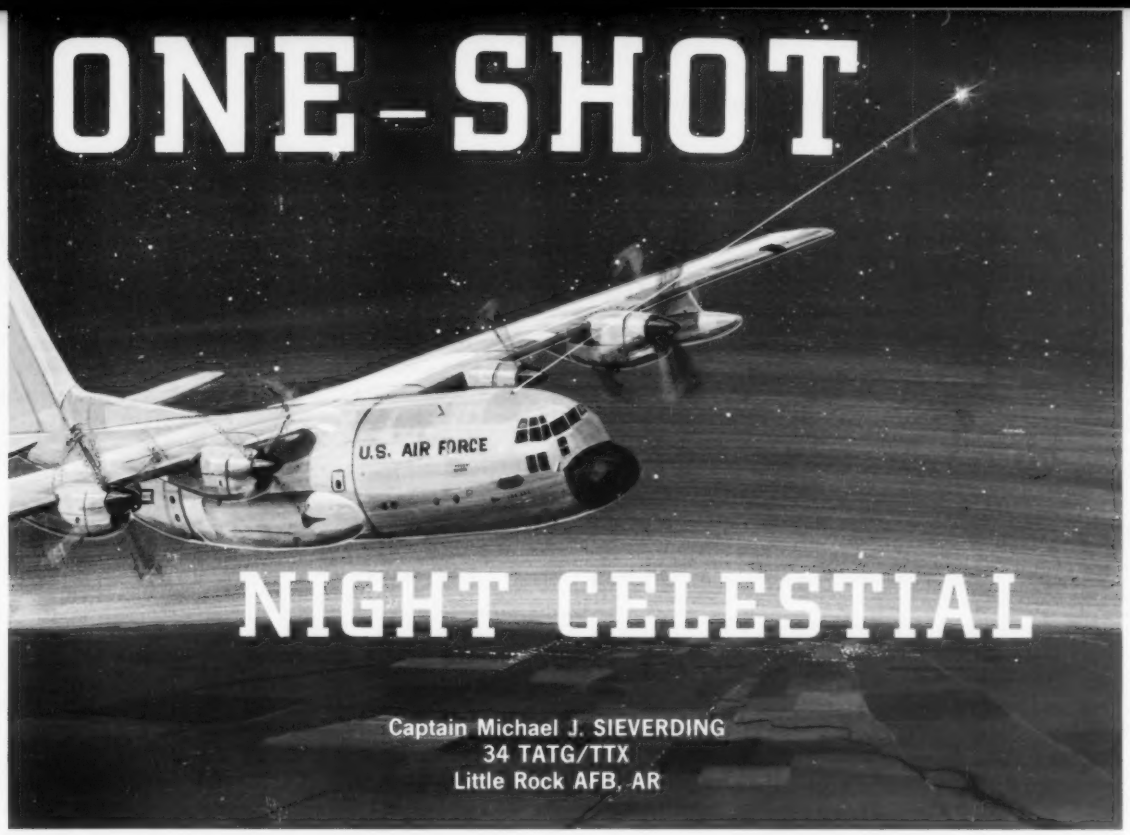
System flexibility will provide another point of view critical to low level mission success. This color coded display could indicate safe flight paths through high terrain.

This simulation mode shows a look-down display which reveals topographic contours of the terrain being overflown.

The Air Force's Avionics Laboratory, sponsor of the development, has explored more than 30 possible uses for this versatile aviation tool. And even though the system is still in experimental stages, crews who have witnessed computer simulations of the Airborne Electronic Terrain Map System are enthusiastic about its future. Yet proof of this lies in the reading, beginning with aircrew and engineering evaluation and human engineering studies after the first working test model is delivered late next year—perhaps the preface to electronic cartography that may eventually free all fliers from needless paperwork.

From Hughes Aircraft Company VECTORS, used with permission.

ONE-SHOT NIGHT CELESTIAL



Captain Michael J. SIEVERDING
34 TATG/TTX
Little Rock AFB, AR

This article presents an updated version of the centures-old subpoint method. A few new wrinkles have been added and most of the complications have been eliminated. This method can gain the same accuracy as a three-star intercept, requires only one observation, demands no in-flight Air Almanac or HO 249 entries, and includes minimal in-flight computation. This method is by no means new, but most navs are unfamiliar with it. Several articles dealing with various aspects of this method have been published in THE NAVIGATOR over the last quarter century. AFM 51-40, Bowditch Vol I, and various command regulations allude to this method in varying degrees of completeness and disguise. I will explain the subpoint method of night cel in an understandable fashion, describe the method's strengths and weaknesses, and give the result of in-flight validation. This method should not be used in-flight as procedure, but is presented for those celestial navigators who enjoy practicing their art.

WHY DOES IT WORK?

If you observed a cel body when your aircraft was directly beneath it (over the body's subpoint), the HO would be 90°-00′. If your aircraft were 60 nm from the subpoint, the HO would be 89°-00′; with an HO of 88°-00′ you'd be 120 nm from the subpoint, etc. If you knew where the subpoint was at the mid-time of your observation you would know your distance from the subpoint. You could plot that distance just like TACAN DME. This version of a noon-time fix occurs infrequently with the sun, but at night there are stars zipping along near your zenith from east to west at frequent intervals.

Every star's subpoint can be determined by using the star's DEC as Latitude and the star's GHA as Longitude by applying the following rules:

DEC = LAT
SHA* + GHA♈ = GHA*
(SHA* means SHA of the star selected.)
If GHA* < 180, then GHA* = West Longitude
If GHA* > 180, then 360 - GHA* = East Long

Your distance from the subpoint can be determined using the following rule:

90° = HO = subpoint distance

If you knew your aircraft true heading (TH) and the IRB of the body at mid-time, you would know the Zn of the body using the following rule:

TH = IB = Zn

Setting your plotter on your DR meridian and plotting this observed Zn toward the plotted subpoint would give you an LOP bearing of the body at mid-time. You could plot it just like a radio aid or radar bearing. This LOP plus the previously mentioned subpoint distance LOP gives you two perpendicular LOPs—a one shot night cel fix, hardly any math and no required in-flight Air Almanac or HO 249 entries. This idea has been kicked around for a long time, but it hasn't entered into our professional repertorie for two significant reasons:

(1) You'd need a big chart with 360° of Longitude spread between your elbows in order to plot the subpoints of any observable body. A fine pencil line would probably be 15 nm wide. Chart projection distortion could cause even greater plotting errors.

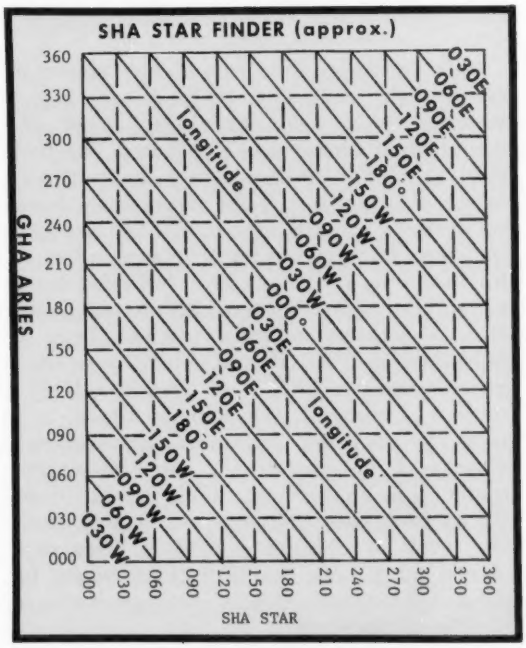
(2) The accuracy of your observed Zn LOP is dependent on the accuracy of your mid-time TH and IRB. Assuming a nominal additive error of 1° in these two variables, you would have a 1° error in your observed Zn. This 1° error at a subpoint distance of 300 nm (HO of 40°) would give your observed Zn LOP an automatic error of more than 52 nm. These huge errors obviously make the subpoint method useful only with certain stars.

Let's consider a star whose subpoint is only 360 nm away from your aircraft. Its subpoint probably could be plotted on a JN-series chart, and certainly plotted on a GNC. You could plot a subpoint distance as accurately as DME or radar range. Refraction could be ignored because of the high HO. Shooting through intermittent clouds would be less of a problem because you're not trying to shoot through them at an oblique angle. That additive 1° observed Zn LOP error would give you a 6 nm observed Zn LOP error. You could get a reliable night cel fix with a two-minute observation. Now the theoretical errors suddenly become manageable, but now another problem exists. How often is the subpoint of one of our 57 selected stars within 360 nm of any given position? Not often. You can't increase the number of observable stars in the heavens. You can, however, increase the number of stars with known SHA and DEC by turning to the star listings in the back of the Air Almanac. Now you have 173 stars to work with. That triples your chances of being within range of a subpoint at any given time. Even so, just what are your chances of being within 360 nm of a subpoint on any mission? After massaging the Air Almanac, the answer appears to be about 50%. This value changes depending on month of the year, direction of flight, and groundspeed. The availability figure increases to 88% if you are flying with a GNC chart that could fit 600 nm distant subpoints on it and you are willing to risk a possible 10 nm error in your observed Zn LOP. Under some conditions, that figure can jump up to 100% or down to 50%. Spending an extra half hour of premission planning can tell you when your route has "subpoint observation windows" available, and if this method can be a reasonable option.

HOW DOES IT WORK?

This example of premission planning assumes that you will be flying with a GNC chart.

First, determine the range of SHA* that will pass through your local meridian during the flight. The graph in Figure 1 will assist you. Enter with the GHA for your expected start nav time. Move horizontally to the Longitude of your start nav position. Move vertically to find the SHA of those stars near your local meridian. Do the same



1. Enter left margin with GHA Aries.
2. Move right (horizontally) to Longitude.
3. Move down (vertically) to SHA star.

All stars with the gained SHA value will be near meridian passage at the observer's Longitude (near 000° LHA star).

NOTE: The SHA value of stars near meridian passage normally decreases with time.

Figure 1

for the GHA and Longitude of your end nav position. The range of SHA* that you have picked out will considerably limit those 173 stars in the Air Almanac.

Second, determine the range of DEC that will pass within 10° of your Latitude during the flight. Look over the Air Almanac star list within the range of SHA* available and select those stars whose DEC is within 10° of your nav leg Latitude. Each star that meets both SHA and DEC criteria will have a useful "observation window" lasting from one to two hours in flight.

Next, plot the DEC of each useful and available star as a constant line of Latitude on your chart. Carefully compute SHA* + GHA = GHA* for selected hourly intervals for each year. Plot GHA* as Longitude on the constant line of Latitude for each star. Now you can shoot these stars at any time during the approximate 90 minute duration of each star's observation window without cracking a book.

Let's suppose you have a 1200Z subpoint of a star on your chart and decide to shoot that body at 1218Z mid-time. Move the 1200Z subpoint 1° Longitude (actual value 1°-00'-10") to the west for each four minutes of time that you shot late. You would move it to the east by the same amount if you shot early. In this case you'd move it 4½° Longitude to the west along that star's constant line of Latitude. Adjust this 1218Z subpoint position for rhumbline/coriolis. There is never any P&N with this method because your DEC and SHA were extracted from a current Air Almanac. All plotting is conducted from this point for this shot. It appears that your 1218Z subpoint is about 200 nm away from your 1218Z aircraft DR. This 200 nm is equivalent to a little more than 3° of HO. Set a little less than 87°-00' into the sextant altitude window. It looks like the subpoint is a five o'clock relative bearing. Turn to that approximate direction and the star should be near the center of your field of view. Collimate the body and begin your shot at 1217Z. Carefully note the body's IRB and TH at the 1218Z mid-time. Complete the shot and resolve the LOPs using 90°-HO = subpoint distance, and TH - IRB = Zn. If you prefer more than two cel LOPs on your chart, shoot the same body a few more times. Plot the LOPs from appropriately adjusted subpoints and resolve the LOPs to a common fix time using track and groundspeed. If you chose to shoot thrice like your three-star intercept brethren, you'd have six LOPs and you wouldn't have had to crack a book. All six LOPs will usually give a slightly different cut because you are very close to a rapidly moving subpoint. A piece of cake. Or is it?

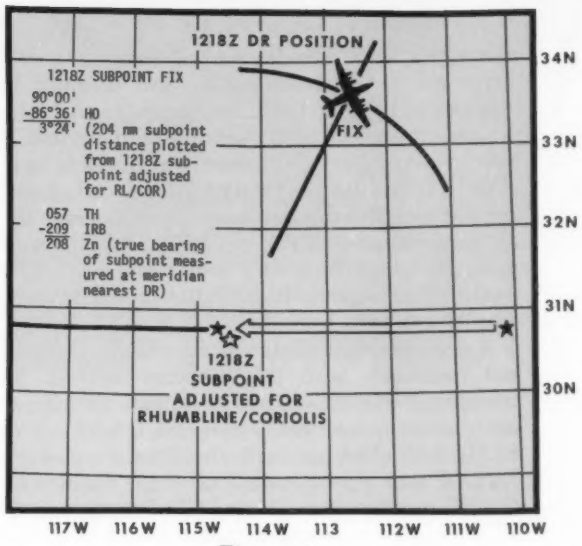


Figure 2

THE REAL WORLD

A test of this subpoint method was conducted on a C-130 night celestial mission recently. Useful stars were selected from the Air Almanac star list using criteria previously mentioned. The stars' DECs and hourly subpoint positions were plotted on a JN-series chart before flight. Neither the Air Almanac nor the HO volumes were consulted during the flight phase. No test observations were made during one hour of the nav leg because no useful stars were within the subpoint observation window of 600 nm.

Thirty celestial observations were made, plotted, and resolved to fix positions with an average fix error of six nm. Fix errors ranged from 0 to 17 nm. A six nm fix error does not represent any significant improvement in cel fix accuracy; however, a celestial position shot, plotted, and resolved every six minutes by one person during a three hour period represents a quantum jump in speed and simplicity.

The test showed that the subpoint method can provide fast and accurate cel positions; however, it also showed that sometimes the subpoint method cannot be used. A listed star's subpoint is not always within a useful observation window. Even though some of the useful stars were quite dim, star identification during the test was surprisingly easy. Here's why.

If a nav were trying to find a star near the horizon but inadvertently turned the sextant to a bearing 5° in error, it could be quite easy to shoot

the wrong star. Five degrees of observed bearing error on a low body could span through five degrees of SHA or DEC. Another star well might be near the center of the sextant field of view. If a nav were trying to find a star near the local zenith (90° HO), but inadvertently turned five degrees in error, those five degrees would span through little (if any) range of SHA or DEC. The nav would have to crank in a very faulty HO or turn the sextant 180° in error to shoot the wrong star when shooting a very high body.

A profound knowledge of star identification is not necessary with the subpoint method. The navigator who conducted this test, by his own admission, cannot tell SCHEAT from SCHEDAR. The test indicated that the observed Zn LOP was most accurate (average 5 nm) when the HO was between 88° and 82°. The average Zn LOP error was 9 nm for HOs between 80° and 82°. The subpoint distance LOP retained an average 3 nm accuracy throughout the full range of test HOs. The test showed that it was nearly impossible to determine the Zn of very high bodies within one degree of the zenith. Regardless of which direction the navigator turned, the star could not be properly collimated. Stars within one degree of the observer's zenith did not yield a reliable Zn LOP. The accuracy of the subpoint distance LOP would also be affected as the nav swung wildly about in the sextant mount chasing the star. After a few attempts of such self-strangulation with the sextant power cable, a method was developed to gain just one LOP (the subpoint distance LOP) from each observation of a very high body. The method can gain two perpendicular LOPs from one body with two observations. The accuracy of this method is excellent (less than 2 nm over five tests). Collimation method for very high bodies (HO more than 88°):

(1) Turn the sextant to either 090° or 270° IRB, whichever direction is toward the body's subpoint. Lock the sextant mount in this position and begin the shot.

(2) Collimate the body so that the bubble is in the middle of the crosshairs and the body is on the horizontal crosshair. It does not matter if the body is displaced from the vertical crosshair. Finish the two minute shot and note the HO.

(3) Unlock the mount and turn the sextant to either 000° or 180° IRB, whichever direction is toward the body's subpoint. Lock the mount in this position and begin another shot of the same body.

(4) Collimate the body as per step (2) above.

Example

1200: HO 89° 10' TH=040
Shot at 270° IRB
(off the right wing)

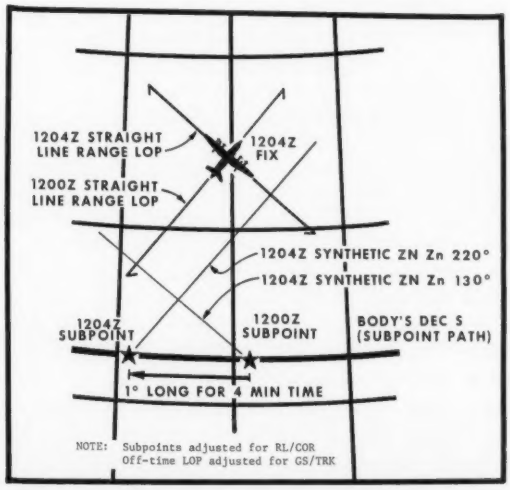
90°-00'
-89°-10'
50' (50 NM subpt dist)

TH-IRB=ZN
040°-270°=130°
Synthetic ZN (true bearing)

1204: HO 88°-46'
Shot at 180° IRB (off the tail)

90°-00'
-88°-46'
1°-14' (74 NM subpt dist)

TH-IRB=ZN
040-180=220°
Synthetic ZN (true bearing)


1204Z STRAIGHT LINE RANGE LOP
1204Z FIX
1200Z STRAIGHT LINE RANGE LOP
1204Z SYNTHETIC ZN Zn 220°
1204Z SYNTHETIC ZN Zn 130°
1204Z SUBPOINT
1200Z SUBPOINT
BODY'S DEC S (SUBPOINT PATH)
1° LONG FOR 4 MIN TIME
NOTE: Subpoints adjusted for RL/COR
Off-time LOP adjusted for GS/TRK

The 1200Z subpoint was 50 nm at a synthetic true bearing of 130°. The 1240Z subpoint was 102 nm at a synthetic true bearing of 220°. Plot the LOPs as standard range and bearing, but with one major difference; plot the ranges as straight line LOPs perpendicular to the respective bearings. The range LOPs should be adjusted to a common fix time, usually the time of the nose/tail shot to gain an accurate speedline. The bearings gained by this method are synthetic and erroneous, only the straight line range LOPs are accurate. The intersection of the straight line range LOPs is the aircraft position. If the aircraft is very close to the subpoint and the nav has no assurance of where the aircraft is relative to the subpoint, the nav could easily get an HS of more than 90°. The sextant can display HSs of up to 92°. No error is associated with this condition if the nav adds 180° to the synthetic ZN when plotting the straight line range LOP. This method disregards standard conventions of collimation and plotting, but gains a highly accurate cel position from a normally untenable celestial situation.

The three-star intercept method has an advantage over the one-shot subpoint method when the sextant has an unknown shooting error. You must know the sextant correction for one shot subpoint to get a fix as accurate as three-star intercept. This can be acomplished by a ramp preflight shot or long-term in-flight verification.

Because of the increased accuracy afforded by the additional LOP, the three-star intercept method has a theoretical advantage over the one shot subpoint method. Theoretically, a three-star fix with exact 120° cuts an area of probability 14° smaller than a two LOP fix with an exact 90° cut. This is a theoretical advantage only because the HO Vol I diamond stars rarely form perfect 120° cuts, whereas the subpoint method always gains a near perfect 90° cut.

The subpoint method is excellent when shooting celestial targets of opportunity. If an aircraft flying through an overcast were to briefly break out into the clear, the nav could set 80° in the sextant altitude window, spin around once through the azimuth ring, shoot any bright body and postcomp a two-LOP fix using procedures previously explained. Fix resolution during a brief break in an overcast is not easily accomplished with conventional cel procedures unless the nav has an excellent knowledge of star identification and at least five minutes of open sky. The subpoint method requires no knowledge of star identification and just two minutes of open sky, but the aircraft must be within useful range of a listed body, i.e., within an "observation window."

The subpoint method of night cel (or day cel) has its obvious strengths and weaknesses. If celestial navigation is an art and the navigator is an artist, a full palette of colors should be available. Subpoint celestial is but one more hue in the spectrum of navigational skills.

The author welcomes any input regarding this method. Please direct correspondence to THE NAVIGATOR.

A 1969 graduate of St Cloud State University, Capt Sieverding was commissioned through OTS. After UNT, he was assigned to Clark AB in the C-130B. Next came assignments to the RC-130A photo mapping, the WC-130 at Keesler AFB, and instructor duty at Mather AFB. Capt Sieverding now is assigned to Little Rock AFB.

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